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ABSTRACT

The process of educating children in our schools has reflected a long history of science and mathematics for males only. Culturally, women and minorities have not made the same progress in society as their male counterparts, education for them being significantly different. These differences, coupled with culturally determined expectations, have resulted in women comprising only three percent of the science, engineering, and business graduates produced by schools today. In order to assist females and minorities to reduce negative aspects associated with the learning of science and mathematics, a range of successful educational policies, programs, and methods are available to help these students. Confronting the social barriers and dealing with the idea of equity in course content, learning activities, and teaching mehtods are necessary steps to ensure females innovative opportunities to increase their skills in math and science. In developing science materials that are relevant to females and minorities, teachers must provide new career models. This will encourage students to clarify their own values and assure them that there are professional opportunities in science for them. Removing the biases from science education will promote the best use of human resources. (LL)

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# ADAPTING THE THINKING PROCESSES TO ENHANCE SCIENCE SKILLS IN FEMALES AND MINORITIES

by

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Paper presented at the Annual Conference of the Institute for Critical Thinking (Montclair, New Jersey, 1990)

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Adapting the Thinking Processes to Enhance Science Skills in Females and Minorities

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For many years, the process of educating children in our schools reflected a preference for basically educating men. An education for a woman was significantly different. Children of minorities suffered from the same malaise. These differences, coupled with culturally determined expectations, have resulted in women comprising only three percent of the science, engineering, and business graduates produced by our schools today. This fact is even more disturbing when viewed from the position that women make up roughly more than 43 percent of the overall population in the United States and 48 percent of our school age population. An informal survey of students entering the Master of Science degree in Early Childhood Education and the Master of Education degree in Elementary Education programs has found that more than fifty percent of these students have elected to work with younger children because they have identified themselves as being "weak" in the areas of mathematics and science. Most early childhood and elementary teachers would indicate that teaching children to read and write ranks higher than teaching, for example, science generalizations that "air has weight" and that "air occupies space." If the deficiencies that these teachers have towards mathematics and science could be further analyzed into daily time spent per subject area, science would be the subject that they would teach if there was time left over in the day.

Culturally, women and minorities have not made the same progress in our society as their male counterparts. Schools, textbooks, and the media still portray women relying on men to do all the tasks that require thinking and the "real doing." Sex-role stereotyping, sends this message: "men invent, and women use the invention!" "Men fly the planes while women serve the passengers." "Men perform surgery while women assist in the cleanup." Clearly, women have been growing up in a male dominated society. No better picture of this dichotomy exists than in our public schools. Where do we find the majority of women teaching? Were do we find a majority of men teaching? Growing up in a society which rewards

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women for allowing men to control their lives supports the notion that if you want to survive in a man's world, you must consider specific careers. Women select careers as a nurse, school teacher--early childhood, elementary, or in the secondary school English or Home Economics. The question raised by this dichotomy is: "Do these differences reflect actual deficiencies found in women and minorities?"

As early as infancy, the treatment that boy and girl babies receive from their parents and caretakers is different. The increased use of amniocentesis is not going to change how we view our children. It will reduce the number of children a family will have. More families will have only one boy. Girls and large families will no longer be the by-products of trying to have boys. Boys will continue to be dressed in blue and girls in pink. True equality for women will not result until society stops viewing females as being weak, helpless, and incapable of logical thought.

Lewis (1972) points out that boys and girls differ in the levels of self-confidence that they develop. While boys are allowed to master their environment, girls learn to depend more on their proximity to adults and less on their own abilities. Other research dealing with parenting styles finds that fathers usually "rough house with their boy babies" while they "cuddle the girls." Mothers, on the other hand, talk more and spend more time teaching their girl babies than they do boy babies. Boy babies are expected to go and find something to do, to play by themselves. Thus, boy babies learn to be independent and self-reliant as well as inductive in their thinking skill. If this initial line of treatment is continued into day care centers, Head Start programs, and public schools--- dependence and deductive reasoning will continue to be fostered in females. Girls have learned from their mothers to develop thinking strategies supported by personal relationships and imitation (deductive reasoning). Boys, on the other hand, find themselves in an environment that promotes independence, risk-taking, and "figuring things out for yourself." Thus, males in our society build a unique set of learning strategies that include: defining goals and objectives, restructuring the situation to accommodate their needs, and abstract basic underlying principles (inductive reasoning) (Lynn, 1972).

Clearly, females have not benefited from reform movements in our schools. A recent study by Sadker, Sadker, and Steindam (1989, p.45) found that "... the reform movement had done little to increase

the academic achievement of females, with 57 percent seeing no increase in their academic performance..." "Girls are the only group who enter school scoring ahead and 12 years later leave school scoring behind." (Saddker, Sadker, and Steindam, p.46).

While there is evidence to suggest the notion that Science Phobia or the anxiety associated with the irrational excessive fear when exposed to any form of science instruction exists and can be found at higher levels in females and minorities than males (Steinkamp and Maehr, 1984), there is evidence to support a difference in motivational orientation. Girls favor those sciences that are related to a maternal role: biology, botany, and chemistry. Boys tend to favor physical science. This is largely due to differences in out-of-school learning experiences (Kelly, 1978). Kelly (1978) reports that while the differences were minimal in biology and chemistry, there were more pronounced differences in physics. "Of the males, 32% intended to major in physics and engineering, whereas only 15% of the females intended to do so" (Steinkamp and Maehr, 1984, p.49).

Science Phobia--a fear of failing or "being viewed as dumb" in science--is a fear more commonly expressed as underachievement in women and minorities (Erickson and Erickson, 1984). This irrational fear is further characterized by: (1) an avoidance of discussions related to science as it impacts upon our daily lives, (2) an avoidance of science and science related courses, (3) low grades in science, (4) an avoidance of any thing "mechanical", (5) an obsession of failing and having to repeat the science courses, (6) sweaty palms and tics in science class, (7) unrealistic goal setting, (8) headaches that go away after science class, (9) an inability to concentrate, (10) insomnia the night before science class, (11) nausea, (12) dizziness associated with being in the laboratory or class, (13) chronic absenteeism, (14) vomiting before, during, and after class, (15) having to frequently urinate or go to the restroom, and (16) destructiveness.

Early differences between males and females in science achievement tests have not been excessively large but increase with age and years in school. "In virtually all countries from which data are available, boys clearly performed better than girls in the physical sciences, especially physics, yet in the biological sciences the boys' advantage has been less apparent and typically small..."(Erickson and Erickson, 1984,p.64). Wendy Schwartz in summarizing the data on

teaching science to at-risk students indicates that"..[m]inorities and women can benefit from long-term programs that can help them recontextualize information, reduce their anxiety, and spend more time on tasks." (Schwartz, 1988, Abstract). In a study of science anxiety among elementary school students, Czerniak and Chiarelott (1985) point out that "...(1) no inherent, biological reasons explain why females should be less adept at science than males; (2) nonthreatening science education is needed for students before grade four; and (3) teachers must be taught about their own science anxiety." (Czerniak and Chiarelott, 1985, abstract). Mallow (1985, abstract)"...points out that children are born with natural curiosity towards science which fades to aversion to the subject as they grow older." Fraser in a study of 2,068 eighth and ninth grade students found that there is an interrelationship between such variables as participation, teacher support, and competition in creating or reducing anxiety associated with science. Perhaps, a lack of female teachers in the sciences during these years, may leave females and minorities with few, if any, role models. The literature (Kelly, 1981) suggests that there may be four factors affecting the development of science anxiety in women and female minorities: the organization of the school, the teaching approaches and curriculum, parental attitudes and careers, and the attitudes or beliefs about science. The degree of science anxiety in our schools today can be highlighted by Vockell and Lobonc (1981) who found that "...[i]n single-sex schools...girls enrolled and achieved in physical science ...as well as in the natural sciences." (Kahle, 1982, p.354). Treatment of girls and female minorities may also account for the development of anxiety towards science. Girls often find ambivalence and messages from other female teachers indicating that they should not get involved in science beginning in the early grades. On the other hand, boys encounter encouragement and career suggestions implied in their interests in science (Brown, Aldrich, and Hall, 1979).

As educators, we must assist girls and minorities reduce their negative aspects associated with the learning of science, especially in the physics and engineering areas. Wendy Schwartz (1987) in another article indicated that a range of successful educational policies, programs, and methods are available to help these students. They are the following: (1) high quality programs with longevity and continuity; (2) high quality diverse staff who are role models for the participants; (3) recontextualization, which allows students to understand the material in the context of their own environment; (4) cultural and language sensitivity; (5) anxiety-reducing strategies; (6)

improved programming; (7) cooperative, heterogeneous grouping of students; (8) creating out-of-school programs and parental support groups. In another publication, Skolnick, Langbort, and Day (1982) suggest four classroom strategies that could be implemented to help females and minorities in the area of science education. The first set of activities focuses on the development of a positive environment of self-confidence and creates an atmosphere that promotes risk-taking when performing science tasks. The second group of activities is centered around the use of simple manipulatives to demonstrate various abstract science concepts. The development of cooperative and group structures in the classroom is the third strategy. These structures allow students to improve their sense of competition, cooperation, and independence. The final classroom strategy supports the creation of new role models and matches course content for equity in the science classroom.

In her study, Matyas (1984), reported that the best predictor of success in a science career for females was the positive feeling about their science classes. However, compared to males, females who were not successful expressed less confidence in their scientific and problem-solving abilities. She also indicated that females reported less frequent participation in curricular and extracurricular science activities. Problem solving and its cognitive processes are closely related to self-confidence. Girls must be provided with the mechanisms that will allow them to believe that they can be successful in science. Some suggested activities are: (1) creating solution sets with a variety of approaches; (2) developing science scenarios that have more than one correct solution; (3) guessing, messing and testing; (4) estimating or approximating the correct answer.

The use of hands-on science activities is also a necessary component for girls to be successful in science. Lawson and Renner (1975) state that "It is the experience with the materials of the discipline that produces the person who can understand abstract content." However, the activities should include opportunities for girls to explore the realm of size, shape, and motion. The use of manipulatives across all grade levels allows girls to make sense out of science because they are related to concrete experiences.

The social arrangement in the classroom is also an important aspect of providing occasions for girls to become actively involved in the science classroom. Every science learning task should be set up

around a unique social arrangement. Activities are structured so that they maximize student participation and interaction in a nonpressured atmosphere.

Confronting the social barriers and dealing with the idea of equity in course content are necessary steps to ensure girls innovative opportunities to increase their skills in math and science. In developing science materials that are relevant to girls and minorities, teachers must provide new career models. This will encourage students to clarify their own values and assure them that there are professional opportunities in science for them. Materials and activities that include, the caring of animals, the growing of plants, designing houses, towns, and parks may be suitable subjects for study by females. These activities when shared with male associates will have a profound impression on both sexes transcending the sex-role boundaries of science.

Removing the biases from science education will allow us to make the best use of our human resources.

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